§1. Improved MHD Simulation for LHD Plasmas with Magnetic Axis Swing

Ichiguchi, K., Sakakibara, S., Ohdachi, S.,
Carreras, B.A. (BACV Solutions Inc.)

A partial collapse observed in the magnetic axis swing experiments in the Large Helical Device (LHD) is analyzed with a magnetohydrodynamics (MHD) numerical simulation.

In the experiments, the background magnetic field is changed during each shot so that the corresponding vacuum magnetic axis position is shifted inwardly [1]. A partial collapse in the electron temperature profile is observed during the shift of the magnetic axis. Thus, we investigate the mechanism of this partial collapse with a numerical MHD approach. To incorporate the change of the background field, we develop a multi-scale numerical scheme, because the time scale of the background field change is much longer than that of the perturbations, The scheme consists of the iteration of time-dependent nonlinear dynamics calculations and updates of a static equilibrium.

Originally, we applied this multi-scale scheme to the analysis of the magnetic axis swing plasma and obtained preliminary results showing pressure collapses [2]. In this analysis, however, the mode is unstable even in the case with the fixed background field, while the plasma is stable in the experiment. In the present analysis, we improve the multi-scale scheme so as to incorporate the change of the rotational transform due to the dynamics as well as the pressure and to use the fixed rotational transform constraint in the equilibrium calculations instead of the zero net toroidal current constraint.

As a result, the situation obtained in the experiments is reproduced in this simulation where the collapse occurs in the case with the change of the field and the plasma is stable in the case without the change of the field, as shown in Fig.1. The collapse results from the fact that an infernal-like mode is destabilized. The destabilization is caused by the change of the background field through the enhancement of the magnetic hill as shown in Fig.2. In the saturation of the mode, the $m = 2$ deformation is generated in the pressure profile, which is caused by the $m = 2/n = 1$ vortices in the core region shown in Fig.3. These mode numbers agree with those of the magnetic fluctuations observed in the experiments.

1) Sakakibara, S., et al., Proc. 23rd Fusion Energy Conf. Oct.11-16, 2010, Deajeon, EXS/P5-13.

2) Ichiguchi, K., et al., Plasma Phys. Control. Fusion, **55** (2013) 014009.

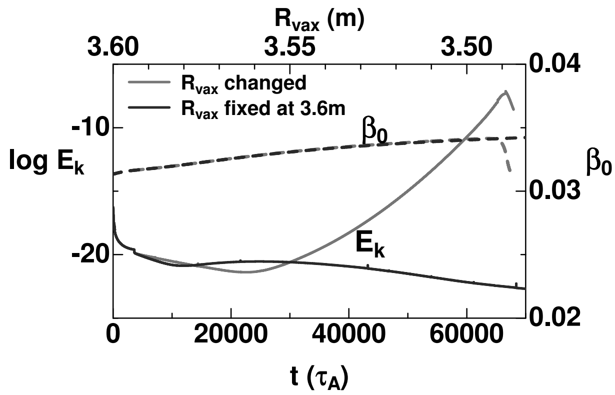

Fig. 1: Time evolution of kinetic energy (E_k, solid lines) of the $n = 1$ component and axis beta (β_0, dashed lines).

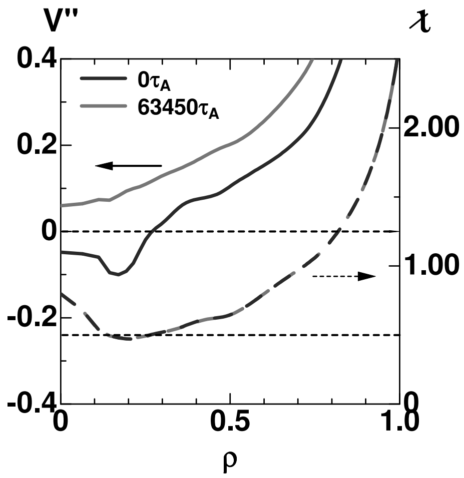

Fig. 2: Profiles of V'' (solid lines) and rotational transform (dashed lines) in the change of the background field.

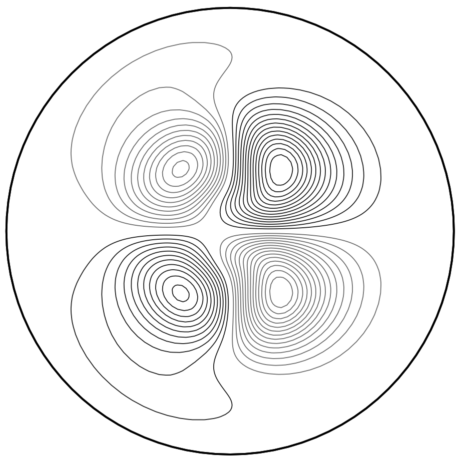

Fig. 3: Stream lines at $t = 66600\tau_A$ in the change of the background field.